# OCA product series

Optical contact angle measuring and contour analysis systems ranging from basic device to fully automated measuring systems for micro-structured samples

dataphysics

# Optical contact angle measurement and drop contour analysis

The optical analysis of drops that hang from a dosing needle or are placed on a solid surface facilitates the determination of different surface and interfacial parameters. The **contact angle** that a liquid drop establishes on a solid surface characterises the solid's wetting behaviour with said liquid.

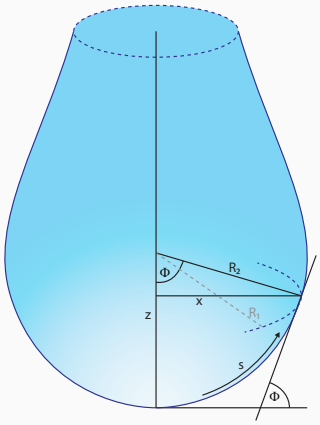
Having measured the contact angles of multiple test liquids the **surface energy of the solid** can be determined and the latter can be used to calculate the work of adhesion for different liquids.

The reliable and experimentally robust measurement of the contact angle aids on the development of surface coatings, composite materials, paints and varnishes or cleaning agents. In short: the measurement of contact angle helps in all situations where solids and liquids meet and advantage is to be gained by the control of wetting and adhesion properties.

## Young-Laplace evaluation

When no other factor is in play a drop of liquid tends to form a sphere, due to its surface tension. The typical drop shape materialises because the drop is elongated due to gravity. The Young-Laplace evaluation of pendant drops recognises this fact: The characteristic shape of the drop profile yields the surface tension $\sigma_L$ of a liquid.

In the case where a pendant drop is surrounded by a second liquid, rather than air, the interfacial tension between the two liquids can be deduced from the drop shape. For optical analysis the outer liquid has to be transparent. Depending on the relative densities, the inner liquid can be dosed either as a pendant drop or upwards, via a bent needle.

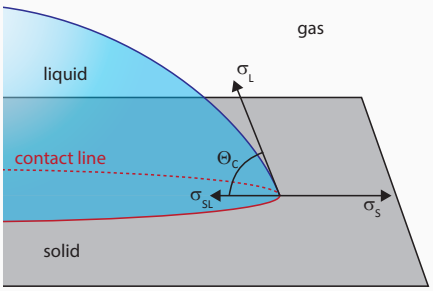


## Young equation

An equilibrium of vectorial forces dictates the **contact angle** $\Theta_C$ at the three phase contact line of a deposited drop. The surface energy of the solid $\sigma_S$ acts along the solid surface. The solid-liquid interfacial energy $\sigma_{SL}$ acts in the opposite direction and the surface tension $\sigma_L$ of the liquid acts tangential to the drop surface. This can be described by a simple scalar equation:

$$\sigma_L \cos\Theta_C = \sigma_S - \sigma_{SL}$$ **Young equation**

The drop is viewed in profile during the contact angle measurement. The image processing software recognises and records the drop contour, as well as the base line at the solid-liquid interface, and fits a mathematical function to the drop shape.



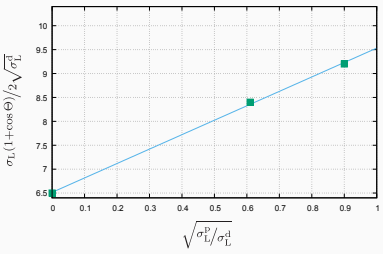

## Surface energy of solids

To determine the surface energy of a solid one measures the contact angles of test liquids whose surface tensions including their dispersive and polar parts are known. These dispersive and polar parts are used to calculate the interfacial tension $\sigma_{SL}$ between the solid and a liquid based on a suitable model. An often applied model is the one of Owens, Wendt, Rabel and Kaelble (**OWRK model**) which considers the geometric mean of the dispersive and polar parts of the liquid's surface tension $\sigma_L$ and of the solid's surface energy $\sigma_S$:

$$\sigma_{SL} = \sigma_S + \sigma_L - 2\sqrt{\sigma_S^d \sigma_L^d} - 2\sqrt{\sigma_S^p \sigma_L^p}$$

Substituting this expression in the Young equation, the polar and the dispersive part of the solid's surface energy can be determined from the regression line in a suitable plot.

The linear regression requires contact angle measurements with at least two different test liquids. However, as a regression line based on just two points contains no information on the accuracy of the result, contact angle measurements with at least three test liquids are recommended for the determination of the surface energy of solids.

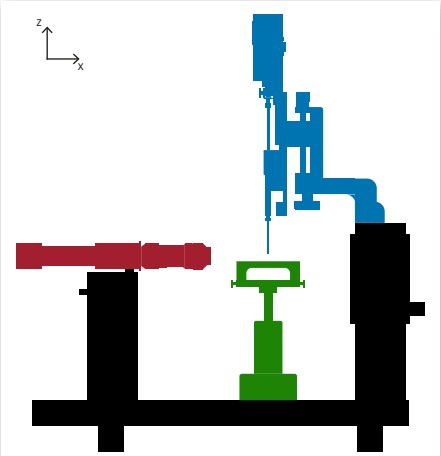



## Lotus effect

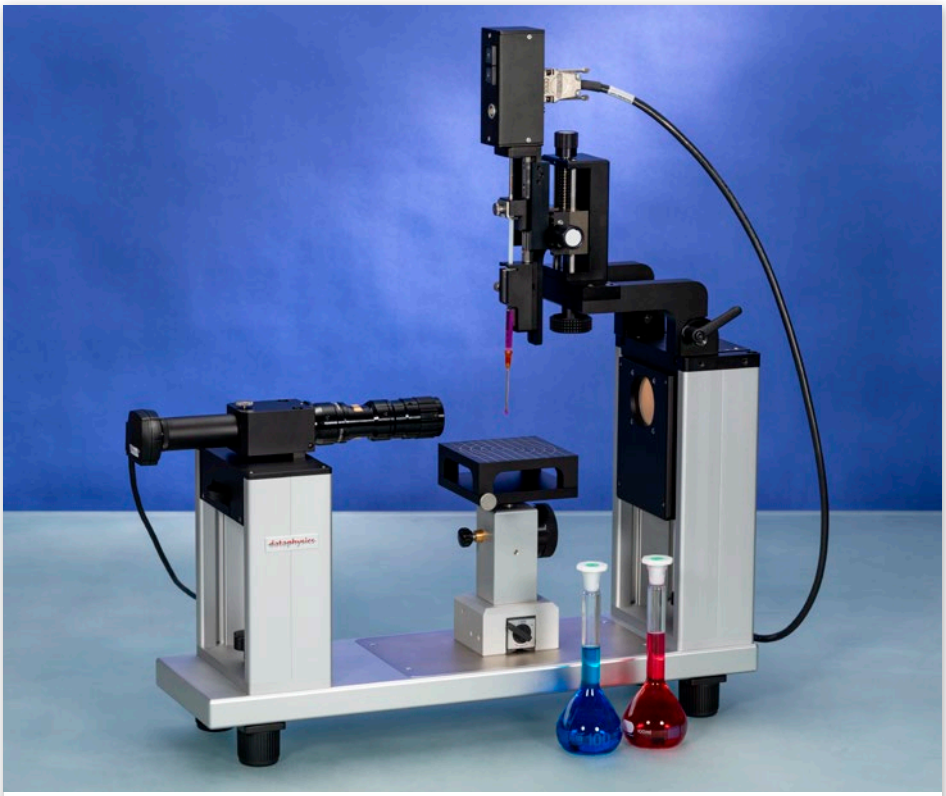
A well quoted example of **large contact angles** can be found in nature: when water droplets come into contact with a lotus leaf they roll off without wetting the surface. During 'roll off' the drops take dirt particles with them, resulting in the self-cleaning of the leaf. Mimicking this "Lotus effect" is a popular research and product development topic in many technical fields. Self-cleaning facades, ceramics and other surfaces are regarded as highly desirable. In this context the ability to measure and record contact angles, of course, plays an essential role.

# OCA models

The optical contact angle measuring and contour analysis systems of the OCA series combine **high resolution optics**, **accurate liquid dosing** and **precise sample positioning** into powerful and reliable measuring systems.



schematic assembly of the OCA models


surface tension measurement using the pendant drop method with an OCA 15EC

The modular approach to all hardware components allows for a multitude of configurations, ranging from **manually operated basic devices** to **fully automated high-performance measuring systems**.

All OCA models are based on a common design philosophy and are built with a **sturdy aluminium metal frame**. Moreover, they all feature a **LED lighting** with manually and software-controlled intensity. Due to an automatic temperature drift compensation a stable and homogeneous illumination of the sample is guaranteed at all times.

## OCA 15EC

The OCA 15EC is the **entry level measuring device** for professional contact angle measurements and drop shape analysis.

The sample table of the OCA 15EC can slide freely in **X- and Y-direction** and is locked into position with its **switchable magnetic base**. In **Z-direction** the sample table is adjustable using **precision mechanics with a hand wheel**.

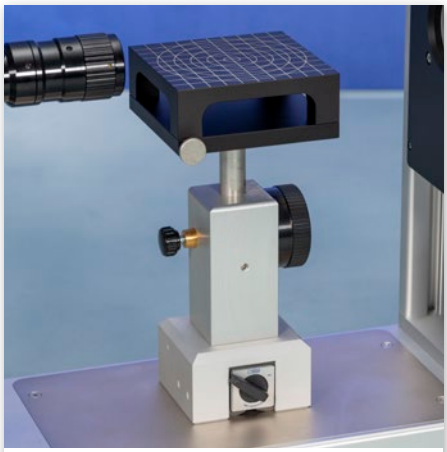
The fast **6.5-fold zoom lens** with manual focus and adjustable observation angle in combination with the **camera with USB 3 interface** ensures pin-sharp drop images and facilitates the effortless analysis with the software.

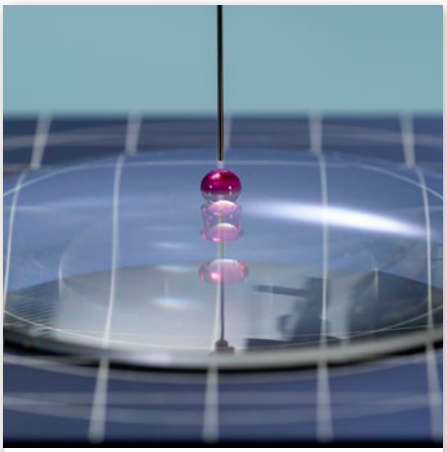
With a **single direct dosing system SD-DM** or a **double direct dosing system DD-DM** liquids can be positioned and dosed with one or two **electronic syringe modules ESr**, respectively. **Direct tubeless dosing** of the syringe content and the ability to use cost-saving disposable syringes and needles allow for short preparation times and minimal cleaning efforts.

Even though the OCA 15EC is a high precision measuring device designed for laboratory use, it is highly mobile and can effortlessly be taken apart with two star grip screws and be stored securely in a transport case.

Due to the modular design philosophy of the OCA series even the entry level OCA 15EC can be combined with most accessories of the vast OCA accessory range.

For example, the **manual tilting base assembly TBA 360M** or – for fully automatic tilting – the **electronic tilting base unit TBU 100EC** make dynamic contact angle measurements far easier. The **FDDS FlexDrop dosing system** also allows multiple drops to be dosed and analysed simultaneously, determining the surface energy at the touch of a button.


sliding magnetic base of the OCA 15EC for free positioning

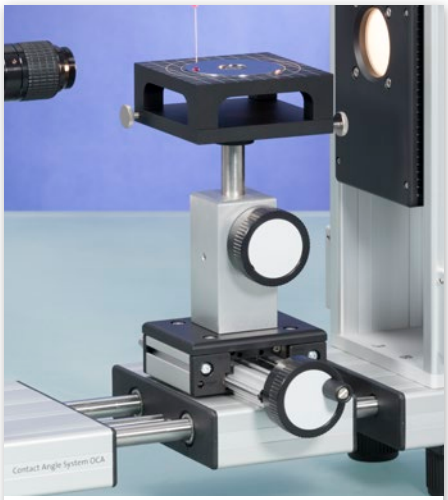

measurement of the contact angle on a curved glass surface

# OCA models

## OCA 25

The OCA 25 is the **all-purpose measuring device** for contact angle measurements and drop shape analysis.

The sample table of the OCA 25 is adjustable along **all three directions in space** via **precision axes with hand wheels**. Hence, a **fast and exact manual positioning** of the sample is always guaranteed, even when using high-performance temperature chambers like the electrical temperature control unit TEC 700U.



OCA 25 sample table with precision axes for exact manual positioning

Analysis of even the fastest processes is possible recording up to **4276 frames/s** using the **6.5-fold zoom lens** and the **high-performance camera with USB 3 interface**. Hence, contact angles on adsorbing surfaces like tissues or powders can be measured reliably.

For dosing liquids the manual single and double direct dosing systems SD-DM and DD-DM can be used as well as the **electronic multiple direct dosing systems DDE/x**. The latter are able to electronically position **one to four electronic syringe modules ESr**.

contact angle measurement with an OCA 25 with a single direct dosing system SD-DM and an electronic syringe module ESr

Furthermore, the **FDDS FlexDrop dosing system** can also be used to generate extra small liquid drops in the **nanolitre range**. Even these are no challenge for the OCA 25 due to its high resolution optics.

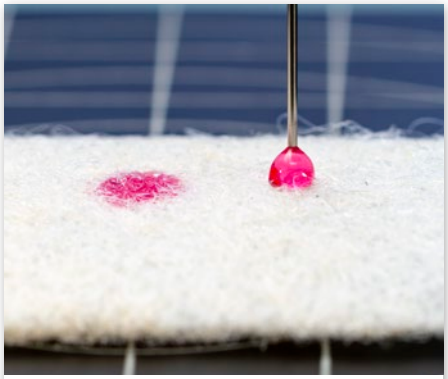
## OCA 25 special models

The universal device platform opens the way to special models of the OCA 25, which satisfy even highest customer expectations and cope with the most challenging measuring environments.

The high temperature measuring system **OCA 25-HTV 1800** is capable of measuring contact angles at high temperatures of up to 1800 °C and under vacuum down to $10^{-5}$ mbar or under inert gas atmosphere, respectively.

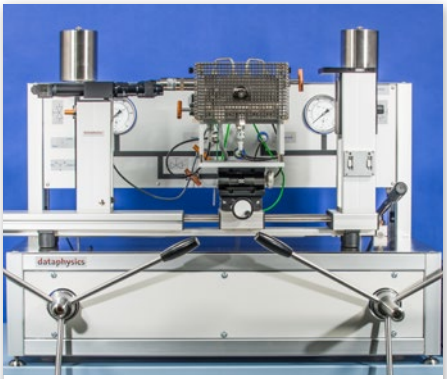
The **OCA 25-PMC 750** with its high pressure measuring chamber provides the opportunity to measure interfacial tensions and contact angles at pressures of up to 750 bar and under high temperature conditions of up to 200 °C.

Further details on these special models can be found in separate brochures.



the adsorption behaviour of liquids on a nonwoven surface can be analysed.

OCA 25-HTV 1800 for contact angle measurements in a high temperature furnace



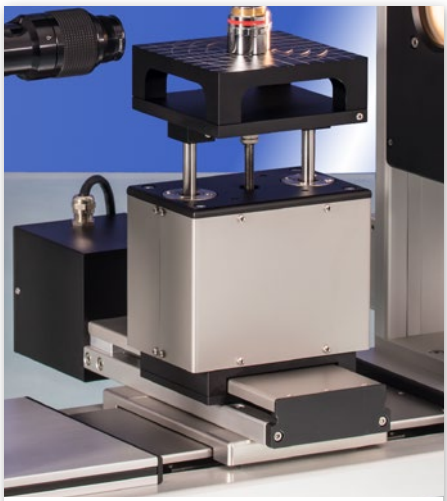
OCA 25-PMC 750 for high pressure contact angle measurements and drop shape analysis

# OCA models

## OCA 50 & OCA 50EC

The OCA 50 is the **fully automatic** measuring device for the time-saving analysis of the wettability of solid surfaces and the determination of the surface energy of solids.

The sample table of the OCA 50 can be positioned along **all three directions in space** via **electronic high-performance axes**, with both **extraordinary speed** and **highest precision**.



OCA 50 sample table with electronic high-performance axes for automatic positioning

12" wafer surface energy 'mapping' using OCA 50L, an electronic direct dosing system DDE/4, four electronic syringe modules ESr and an electronic turn table with vacuum fixation ETTr/VAC.

Combined with an **electronic multiple direct dosing system DDE/x** and up to **four electronic syringe modules ESr** the determination of surface parameters can be automated completely.

The automation of measurements succeeds easier than ever before thanks to the intuitive automation dialogue of the software and its visual drop positioning system. Hence it is possible to determine, for example, the surface energy with four test liquids at different position of even large samples without any manual user intervention. This facilitates a complete and automated sample mapping.

In order to map silicon wafers, **electronic turn tables with vacuum fixation** are available. Combined with the extended axes of the OCA 50L device variant, this allows any position to be accessed for contact angle measurements even on 12" wafers – further information on the **OCA 50L** is available on request.

In any case, the **6.5-fold zoom lens** and the **high-performance camera with USB 3 interface** ensure optimal images of the deposited drops.

For a fast and intuitive device control, even during complex measurements, the **TP 50 control panel with touch screen and precision control wheel** is included with every OCA 50.

determination of advancing and receding contact angles using dynamic contact angle measurement on a tile with an electronic tilting base unit TBU 100.

OCA 50EC with direct dosing system DDE/3 and three electronic syringe modules ESr

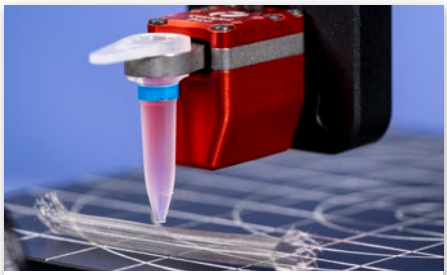
# OCA models

## OCA 200

The OCA 200 is the contact angle measuring and drop contour analysis system for **microscopic and macroscopic structures**.

The **software-controlled, electrically driven optic alignment** enables the OCA 200 to adjust the observation angle and to **focus automatically**.

With the trendsetting **10-fold zoom lens** and the reliable **auto focus system** by DataPhysics, the OCA 200 is equipped to handle any kind of sample size from a macroscopic silicon wafer to the microscopic mesh structure of a coronary stent.

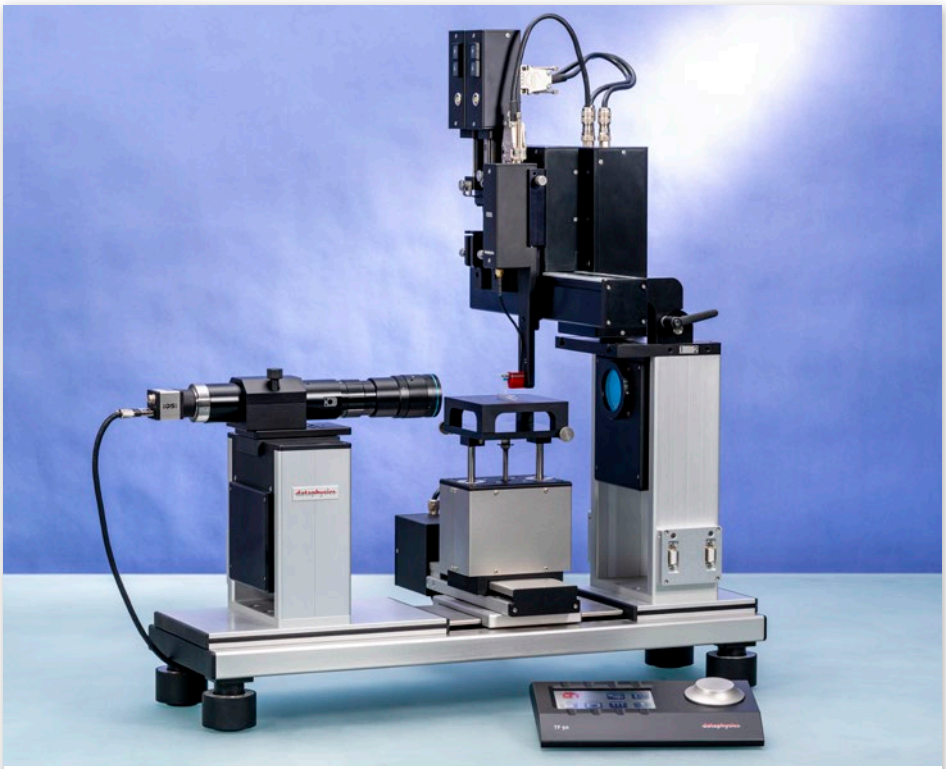


contact angle measurement on a coronary stent with the FDDS FlexDrop Pico.

In combination with the **high-performance camera with USB 3 interface** even smallest drops of highly volatile liquids can be monitored.

The **electrically driven sample table** makes it possible to position micro-structured samples with **highest precision** and **exceptional speed** for fast automated measuring procedures.

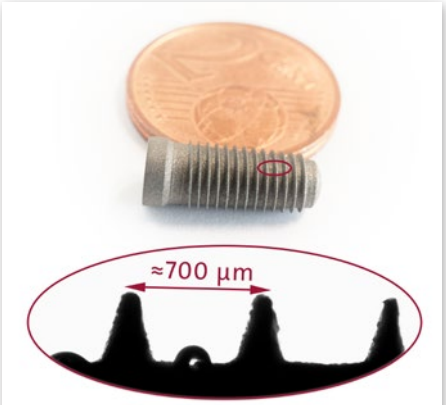
With an **electronic multiple direct dosing system DDE/x** and up to **four electronic syringe modules ESr** liquids can be deposited on a macroscopic sample and its surface parameters can be determined automatically.



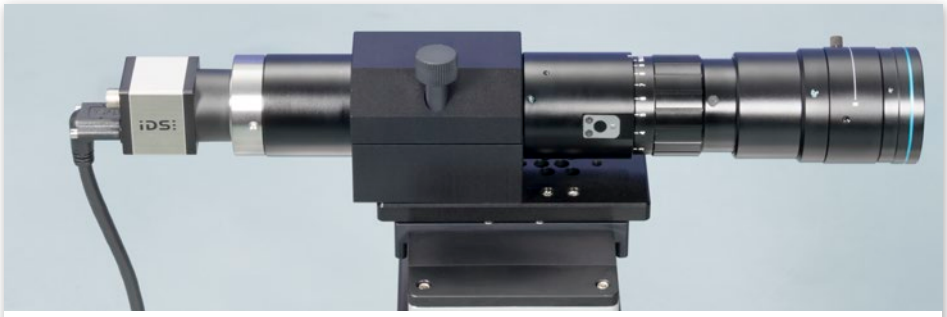
contact angle measurements on micro-structured samples using an OCA 200 with FDDS FlexDrop dosing system.

For the analysis of micro-structured samples, the **FDDS FlexDrop dosing system** is available. In its **Nano variant**, it generates drops from as little as **2 nl** – these fit, for example, into the screw threads of a dental implant, allowing its surface to be examined.

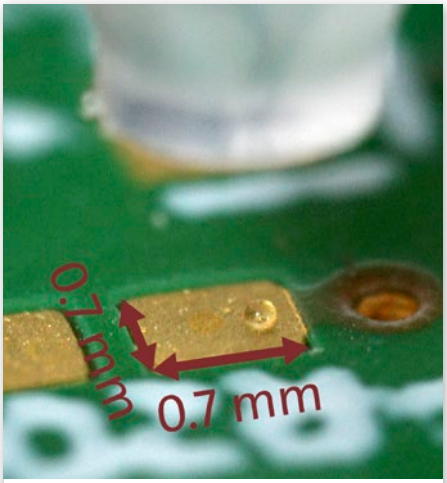
For even smaller structures, the **Pico variant of the FDDS** offers the possibility of dosing droplets as small as **25 pl**. This allows measurements to be taken, for example, on the metal struts of a coronary stent or on microelectronic components.




nanolitre drop between the screw threads of a dental implant



trendsetting 10-fold zoom lens with software-controlled optic alignment for adjusting the observation angle and for autofocus




picolitre droplets on the contact pads of a printed circuit board

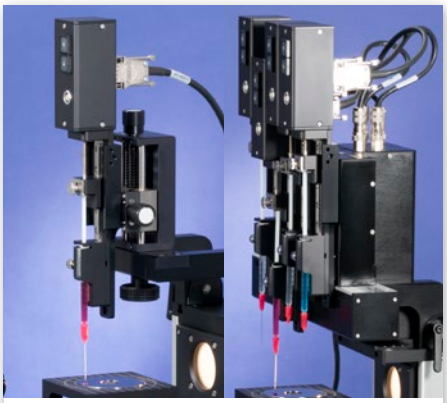
# Wide range of accessories

With the **manual** and **electronic direct dosing systems**, electronic syringe modules ESr as well as the FDDS FlexDrop dosing system can be easily positioned above the sample table, allowing a choice of up to four liquids.

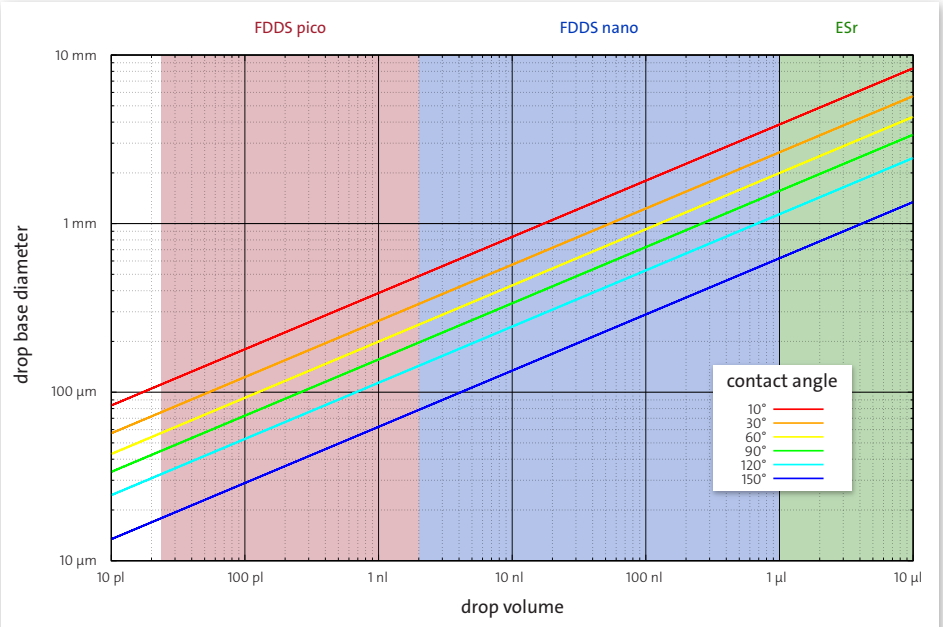
The **electronic syringe modules ESr** can be equipped with glass or disposable syringes and typically dose drops as small as **1 µl**, allowing macroscopic samples to be conveniently examined.

For micro-structured samples, such as precision mechanical components, medical implants, printed circuit boards, or single fibres, the **FDDS FlexDrop dosing system** can instead be mounted onto the direct dosing systems, reproducibly dosing droplets as small as **2 nl** and **25 pl**, respectively. Further details are found in a separate data sheet.

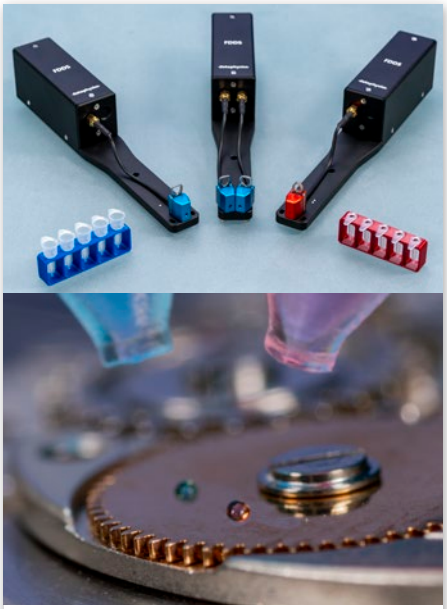
electronic syringe module ESr



l: single direct dosing system SD-DM
r: electronic direct dosing system DDE/4




approximate drop base diameter as a function of drop volume and contact angle

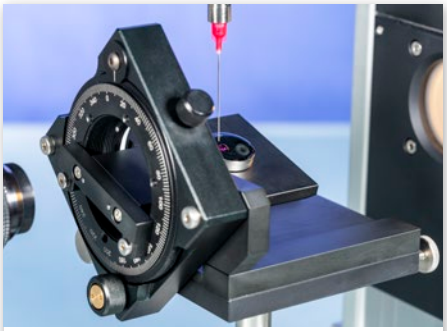


FDDS FlexDrop dosing system for nano- and picolitre droplets

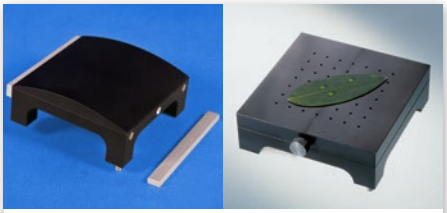
For a firm fixation of the samples on the sample table DataPhysics offers multiple options. The sample table **STC 100** features **holding clamps** that reliably and easily fix flat samples like glass slides. Films or fabric on the other hand can be spanned over the **curved sample table FHM 100** and to which they are fixed with lateral magnetic bars. The **suction plate SP 100** is designed to hold especially flexible samples flat on its suction area, while single fibres are conveniently positioned spanned into the **single fibre holder FHO 40plus**.

The **electronic tilting base units TBU 100 & 100EC** fully automatically tilt the entire OCA device in a range of **-5° to +95°** including attachments like dosing systems and environmental chambers. This permits dynamic contact angle measurements according to the tilting method and allows determining the advancing and receding contact angle and contact angle hysteresis as well as the 'roll off' angle for a certain drop volume.

electronic tilting base unit TBU 100EC
for dynamic contact angle measurements



manual tilting base assembly TBA 360M



l: curved table with magnetic bars FHM 100
r: suction plate SP 100

# Wide range of accessories

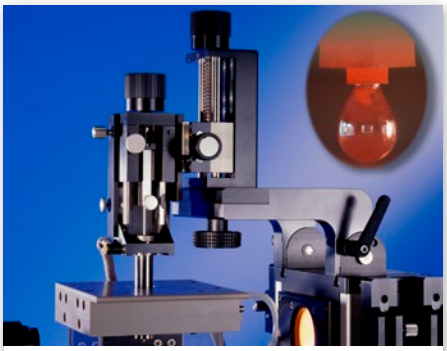
Pursuant to the modular design of the OCA series, DataPhysics provides a wide range of accessories facilitating measurements under various environmental conditions.

With different **environmental chambers** measuring temperatures from **-30 °C to 700 °C** can be reached. Dedicated to investigating the properties of metals, polymers or hotmelts in their liquid state is the **electrical needle heating device NHD 700U**. This special piece of development enables the dosing of **molten solids at temperatures up to 700 °C**. Hence the surface tension of, for example, molten aluminium can be determined.

The **humidity generators of the HGC series** allow for a reliable control of the **relative humidity** in the range of **5 % to 90 %**. The HGC instruments are connected to the environmental chambers from DataPhysics but can also be used with those of other suppliers.

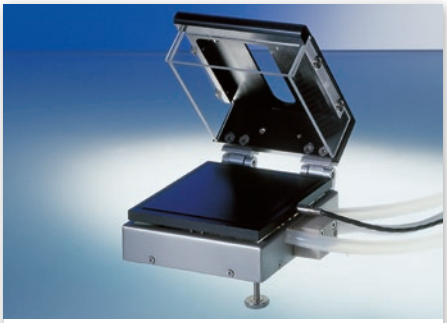
Further details on the HGC series and the thermal solutions are found in separate data sheets.

humidity generator HGC 30



electrical needle heating device NHD 700U

liquid temperature control unit TFC 100Pro for temperatures of -10...100 °C



Peltier temperature control unit TPC 160U for temperatures of -30...160 °C

TP 50 control panel with touch screen and precision control wheel

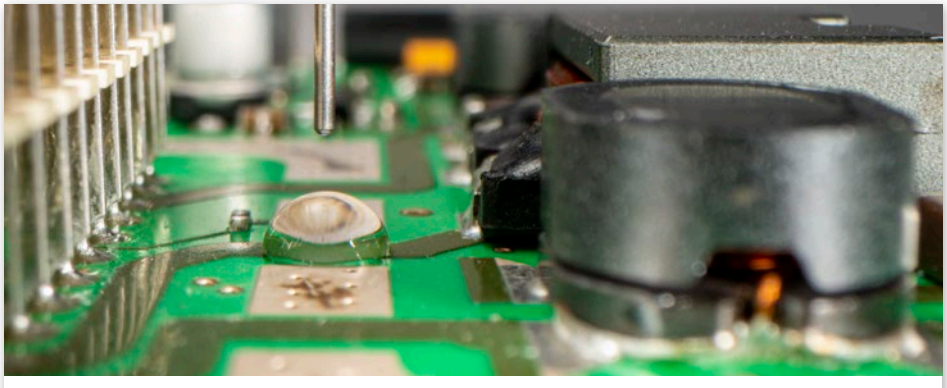
The **TP 50 control panel with touch screen and precision control wheel** establishes a comfortable and **intuitive control** of **all electrical components** of the OCA series, ranging from the electrically driven sample table over the electronic dosing systems up to any additionally attached modules such as a humidity generator. The precision control wheel allows to make settings exceptionally fast and still with the highest accuracy.

The **Topview Video System TVS** opens up a completely new approach to contact angle measurement. With this system deposited drops are monitored and evaluated in topview which allows to investigate previously inaccessible sample spots, for example, at the bottom of indents of ready-made components or on assembled printed circuit boards. Moreover, the TVS enables the determination of surface homogeneity and surface isotropy.

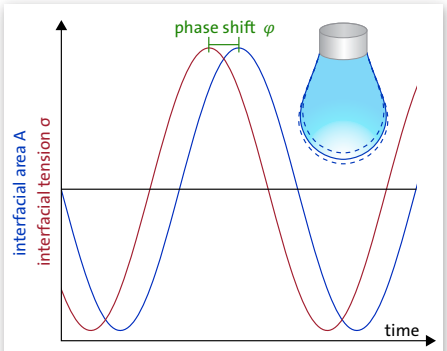
For **interfacial rheology studies** on oscillating drops, the **electronic syringe module for oscillation ESr-M** is available. It generates sinusoidally oscillating and relaxing drops. The phase shift between interfacial area and interfacial tension can be used to determine the **viscoelastic modulus of surface-active substances** – relevant, for example, for assessing the stability of emulsions and foams in food products or pharmaceuticals.

The **optical standards OCAS** allow the measuring performance of OCA devices to be checked and verified at any time, using glass slides with precisely defined sessile and pendant drop contours.

More information on these and many other accessory options are found on the DataPhysics Instruments website.



Contact angle measurement on a printed circuit board using Topview Video System TVS

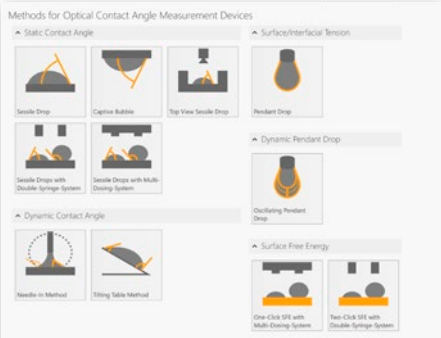



Viscoelastic modulus based on the phase shift of interfacial area and tension

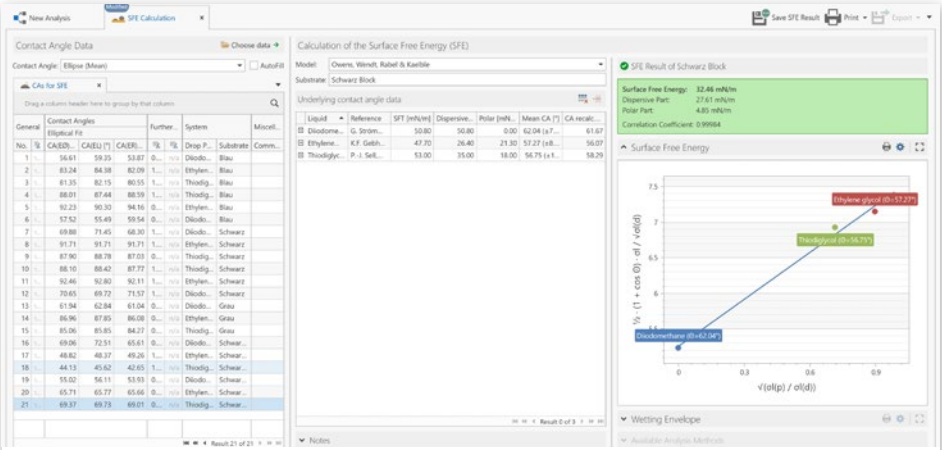
# Comprehensive software

dpiMAX is *the* innovative and easy-to-use software companion for the optical contact angle measuring and contour analysis systems of the OCA series. The software makes measuring with OCA systems easier and more comfortable than ever before.

dpi**MAX** helps you to
**M**easure your samples quickly,
**A**nalyse the results easily and
**X**plore your data intuitively.



overview of measurement methods



easy determination of a solids' surface energy

**Smart and helpful functions**
dpiMAX is a software designed to smoothly guide the operator through the entire process of performing measurements, analysing data, and reporting results. dpiMAX not only controls the measuring device and performs analysis algorithms, but also supports the operator with an intuitive user-interface as well as numerous helpful and smart functions.

Throughout, dpiMAX keeps the operator focused on the task at hand, showing only the information necessary at any moment. During a measurement, only the drop image and the results table are displayed, alongside a tailored control panel, which is comprised exclusively of the settings and device controls needed for the current measurement method.

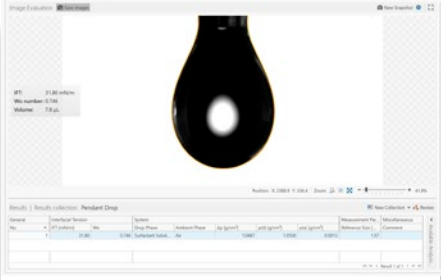
**Instant drop image evaluation**
Evaluating drop images with dpiMAX is quick, reliable, and convenient. As soon as a drop is dosed, dpiMAX automatically recognises its shape and instantly determines the pendant drop's surface tension, or the sessile drop's contact angle, respectively. The operator can also choose to record the entire measurement as a video.

But even if they forgot to start the recording: the measurement is not lost thanks to dpiMAX's special Instant-Replay-function. This function allows the operator to wind back to an important moment just missed, which can then still be analysed.

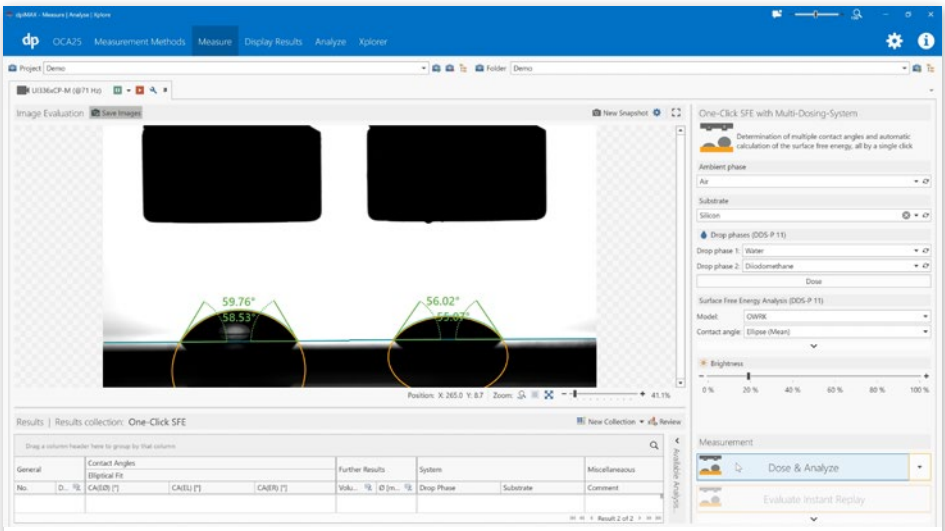
**Well-organised data storage**
Whenever an operator measures a sample with dpiMAX, or performs an analysis, the data created is automatically saved. It is accessed via the well-organised Xplorer, from which the operator can load previous results for graphical representation, for comparison, to add more measurements, or to perform further analyses.

**Simple operation and powerful options**
dpiMAX is a software for everyone: beginners are guided by the method-specific control panel, while experienced operators will value the possibility to adjust various parameters, such as expert camera settings, when facing demanding measuring situations.

dpiMAX can also run simple one-click measurements, which supports especially operators having to conduct repetitive tasks. Hence, the multi-lingual software dpiMAX is valued in development and quality control departments just as in research labs all over the world.



surface tension measurement



simultaneous contact angle measurements of two test liquids for surface energy determination

# Available measuring methods and technical data

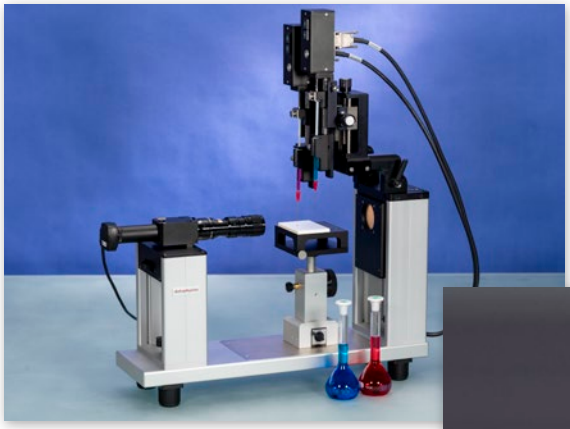
| | OCA 15EC | OCA 25 | OCA 50 | 50EC | OCA 200 |
|---|---|---|---|---|---|
| **Contact angle** | ○ | ○ | ○ | | ○ |
| measuring range | 0 ... 180° | 0 ... 180° | 0 ... 180° | | 0 ... 180° |
| accuracy | ± 0.1° | ± 0.1° | ± 0.1° | | ± 0.1° |
| resolution | ± 0.01° | ± 0.01° | ± 0.01° | | ± 0.01° |
| **Surface and interfacial tension** | ○ | ○ | ○ | | ○ |
| measuring range | 0.01 ... 2000 mN/m | 0.01 ... 2000 mN/m | 0.01 ... 2000 mN/m | | 0.01 ... 2000 mN/m |
| resolution | ± 0.01 mN/m | ± 0.01 mN/m | ± 0.01 mN/m | | ± 0.01 mN/m |
| **Surface energy** | ○ | ○ | ○ | | ○ |
| **Liquid bridge analysis** | ○ | ○ | ○ | | ○ |
| **Oscillation / relaxation** | ○ | ○ | ○ | | ○ |
| **Topview contact angle** | — | ○ | ○ | | ○ |
| **Sample table** | sliding magnetic base | manual precision axes | electronic precision axes | | electronic precision axes |
| traversing range (X-axis [mm] x Y-axis [mm] x Z-axis [mm]) | 110 x 90 x 42 | 100 x 104 x 42 | 100 x 105 x 50 | | 100 x 105 x 50 |
| traversing speed (X-axis) | — | — | 75 nm/s ... 18 mm/s | | 75 nm/s ... 18 mm/s |
| traversing speed (Y-axis) | — | — | 75 nm/s ... 21 mm/s | | 75 nm/s ... 21 mm/s |
| traversing speed (Z-axis) | — | — | 75 nm/s ... 20 mm/s | | 75 nm/s ... 20 mm/s |
| positioning resolution | — | — | ± 39 nm | | ± 39 nm |
| max. sample weight | 3.0 kg (locked Z-axis: 15.0 kg) | 3.0 kg (locked Z-axis: 15.0 kg) | 10.0 kg | | 10.0 kg |
| **LED-lighting** with manual and software-controlled intensity including automatic temperature drift compensation | | | | | |
| warm-white LED (3000 K) | ● | ● | ● | | ● |
| monochromatic red LED (660 nm) | ○ | ○ | ○ | | ○ |
| monochromatic blue LED (465 nm) | ○ | ○ | ○ | | ○ |
| **Temperature and environmental control** | | | | | |
| temperature chambers (-30 °C to 700 °C) | ○ | ○ | ○ | | ○ |
| electrical needle heating device (RT ... 700 °C) | ○ | ○ | ○ | | ○ |
| humidity generator of the HGC series | ○ | ○ | ○ | | ○ |

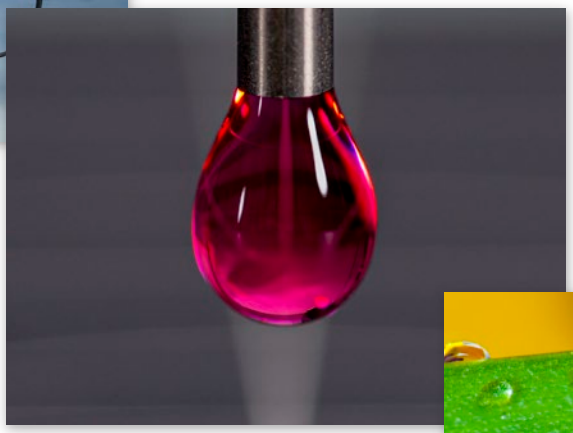
● integrated ○ with optional software/accessory — not available

| | OCA 15EC | OCA 25 | OCA 50 | 50EC | OCA 200 |
|---|---|---|---|---|---|
| **Optics** | | | | | |
| 6.5-fold zoom lens with integrated manual focus (± 6 mm) | ● | ● | ● | | — |
| 10-fold zoom lens with software-controlled focus (± 4,5 mm) and observation angle (-9° ... +2°2') | — | — | — | | ● |
| **field of view** (X min x Y min) ... (X max x Y max) | | | | | |
| (1.11 mm x 0.83 mm) ... (7.14 mm x 5.35 mm) | ● | — | — | ● | — |
| (2.50 mm x 1.33 mm) ... (16.09 mm x 8.55 mm) | ○ | ● | ● | ○ | — |
| (1.12 mm x 0.58 mm) ... (11.29 mm x 5.98 mm) | — | — | — | — | ● |
| **Camera system** | | | | | |
| USB 3 camera, 1/3" sensor<br>max. resolution 1440 x 1080 pixel with 227 frames/s,<br>max. frame rate 3246 frames/s | ● | — | — | ● | — |
| USB 3 camera, 2/3" sensor<br>max. resolution 2048 x 1088 pixel with 170 frames/s,<br>max. frame rate 4276 frames/s | ○ | ● | ● | ○ | ● |
| high-speed camera system | on request | on request | on request | | on request |
| **TP 50 control panel** | ○ | ○ | ● | ○ | ● |
| **Dimensions** (L [mm] x W [mm] x H [mm]) | 550 x 160 x 365 | 660 x 220 x 365 | 680 x 310 x 370 | | 680 x 310 x 370 |
| **Weight** | 14 kg | 16 kg | 26 kg | | 28 kg |
| **Power supply** | 100 ... 240 VAC;<br>50 ... 60 Hz; 70 W | 100 ... 240 VAC;<br>50 ... 60 Hz; 70 W | 100 ... 240 VAC;<br>50 ... 60 Hz; 70 W | | 100 ... 240 VAC;<br>50 ... 60 Hz; 70 W |

● integrated ○ with optional software/accessory — not available

dataphysics





**We will find a tailor-made solution for your surface science use case and will be pleased to provide you with an obligation-free quotation for the system that fits your needs.**
**For more information please contact us.**

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